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BEFORE THE

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SEPTEMBER 10, 1984—THE ROLE OF UNIVERSITIES IN HIGH TECHNOLOGY DEVELOPMENT

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THE ROLE OF UNIVERSITIES IN HIGH TECHNOLOGY DEVELOPMENT

MONDAY, SEPTEMBER 10, 1984

CONGRESS OF THE UNITED STATES,
JOINT ECONOMIC COMMITTEE,
Washington, DC.

The committee met, pursuant to notice, at 10 a.m., in room 2203, Rayburn House Office Building, Hon. Daniel E. Lungren (member of the committee) presiding.

Present: Representative Lungren.

Also present: Charles H. Bradford, assistant director; and William R. Buechner and George Krumbhaar, professional staff members.

OPENING STATEMENT OF REPRESENTATIVE LUNGREN, PRESIDING

Representative LUNGREN. Good morning.

Surviving in the international world of trade today demands that companies keep abreast of technological developments as they've never done before. The pace of technological progress is such that those who first successfully implement new technologies often gain a substantial competitive edge over those who are slower.

One would think that this country, with its magnificent educational institutions and impressive technological achievements, would be first in this regard. Yet the evidence does not always point this way. As one observer wryly put it, "The United States walks away with the Nobel Prizes and the Japanese have the trade surplus." In addition, there are trends in our scientific-educational community that give us some concern for the future strength of the scientific establishment.

This hearing is designed to examine the link between the basic research and education that takes place at the university level and the utilization of advanced technology and educated manpower at the user level.

Additionally, the hearing will attempt to identify those Federal policies that promote and those that impede the process of technological transfer between university and industry.

The witnesses have been chosen to bring different perspectives to the issue and they will enable the committee to contrast the problems faced by different kinds of educational institutions.

We, of course, have a long row to hoe. We face acute faculty shortages in science and engineering. Technology has made science and engineering education increasingly more expensive, and that

presents its own challenge to our institutions. Educators are questioning the quality of students entering college as science and engineering undergrads. We have an issue before the Congress on immigration, and one of the aspects there has to do with the foreign-born student and whether that student has to return to his home country for a couple of years before he has the right to either work as a professor in our universities or work in our high-tech field.

Additional barriers to industry-university cooperation still exist, and in some cases, I think we could probably agree, perhaps rightly so.

Federal policy has a role to play in providing the setting where innovative research can take place and where industry needs for technology and educated manpower can be met. This takes money, enlightened tax policies, a forward-looking approach to patents and a national drive for higher standards—or the highest standards in schooling.

We hope this hearing will give us the information we need to make some informed judgments on these important matters.

We've had a series of hearings around the country and here in Washington with respect to the whole question of entrepreneurship and the transfer of technology from academia to the marketplace, the need for training people so that that can be done, and we believe that this hearing is one of the most important in that series.

We have three members of the panel here today: John Kotula, president of Delaware Technical and Community College; Don Langenberg, chancellor of the University of Illinois at Chicago; and Joseph Pettit, president, Georgia Institute of Technology.

We welcome your appearance here. I would just say that because we would like to get some question and answer exchange, we would like you to keep your initial comments or statements to 10 to 15 minutes, then we could engage in questions. And I hope I can get some different responses from you, because you have different perspectives.

Let me go from my right to left and introduce first, Joseph M. Pettit, the president of Georgia Tech, a State university, since 1972, formerly dean of the School of Engineering at Stanford. Mr. Pettit chairs the Education Advisory Board of our National Academy of Engineering, sits on the Department of Defense's university forum and on the board of directors of several corporations. Therefore, he brings us a unique government, industry, and university viewpoint.

Mr. Pettit, we welcome you here and would invite you to proceed as you wish.

STATEMENT OF JOSEPH M. PETTIT, PRESIDENT, GEORGIA INSTITUTE OF TECHNOLOGY, ATLANTA, GA

Mr. PETTIT. Thank you, Congressman. I have a handout here, which I trust you have in front of you. Given the late invitation to come to this hearing, I have to express some gratitude to high technology for having something here in writing. I have a computer at home and I can do word processing and run it through a copier at the office; it never saw a typewriter.

Representative Lungren, just to set a little historical and geographic perspective which might make me most useful to your com-

mittee, let me quickly mention that I graduated from Woodrow Wilson High School in your home city, and that one of your political forebears, Craig Hosmer, was a classmate of mine. That gives you some idea of my antiquity, perhaps.

I think one interesting aspect of that is that I was in California, I was at Berkeley, I was at Stanford, all before there was a Silicon Valley. People tend to think that there always has been a Silicon Valley. There was not, and it was clear to a graduate in electronics in those days that the only employment was on the east coast. In fact, my predecessor, Dean Frederick Terman, in 1940, was elected president of the Institute of Radio Engineers, one of the forerunners of the current Institute of Electrical & Electronics Engineers. He was the first president to be elected from west of Rochester, NY. So there's been quite a migration in the industry and it has, of course, concentrated in certain areas for particular reasons.

I mention this because it may suggest a line of questioning later, if you wish to pursue that further.

I was a witness and a participant in the growth of Silicon Valley and know some of the things that went on. History keeps being rewritten, of course. Some of it needs a little clarification.

The chairman of your committee signed a letter that came to me a few days ago. It had some major topics, so I have my outline of commentary here, based really on that. I gather from your introductory remarks that you're looking at the university role in high technology development, and in particular, the university/industry/Government cooperation as a potential element in that.

Quickly, I affirm that universities do have an important role in high technology and the U.S. economy, and mention a few historical examples of high technology, things that came from university campuses. I could add many more, the laser at Harvard, and so on.

Some things, of course, came strictly out of industry, like Du Pont and nylon, but many things did not.

The transfer into the marketplace and particularly the international marketplace is something that we can't take for granted, and that's something I know you're looking at. I believe that there is a future potential that's even higher than the past and present, and that there is a Federal role in developing it. I mention that a lot of the current progress is due to the good working partnership between universities and the Federal agencies, but new efforts to bring a third partner, industry, needs further development.

In this cooperation, I think the most important aspect, it's one of the questions raised, is a mutual understanding of the unique roles of each of these three quite different institutions in society—the corporation, the university, and the Federal Government. And for that matter, the State government, as well.

They have different central purposes. This need not be exaggerated, however, because if you consider a drawing something like the Olympic symbol of overlapping circles, I think you can have three overlapping circles here with substantial common areas, in which cooperative work can be done.

Understanding of the university, I think, is a special challenge. I was at Harvard, during World War II, when a lot of university people were there. Our lab there was an outgrowth of the MIT Radiation Lab, and there were many academics there also who hit the

road as soon as the war ended and went straight back to their universities. They're still there. There was a realization, however, that here was a resource that could not be tapped by trying to lure them into Government laboratories or in some other mode, but rather to take the support or their creative work to the universities where they were.

Now this was not totally ignored prior to World War II, except the only mode that the Federal Government seemed to operate then was either recruiting of graduates or procurement of hardware, not much set up for procurement of ideas and cooperation. After World War II there developed ONR, Office of Naval Research, first, and eventually, the National Science Foundation came into being, and whole new ways of doing business between Government and universities began to evolve.

I think we have yet to see them evolve between industry and universities.

Successful modes of cooperation are numerous, I mention only one or two, between the Federal Government and the universities. DOD and NASA represent interesting cases. They did devise very early ways of sponsoring work in the universities, and they were unique as funding agencies, in that they also have the authority for development, for procurement and utilization. There was a clearly established avenue for technology transfer and utilization.

I mention next that universities are best when they're contributing to knowledge. And it doesn't mean just abstract knowledge, pure knowledge. It means contributing to the knowledge base, even in very applied fields like engineering or medicine. And some universities go beyond this. And I mention my own, because I was attracted very early in going to Georgia Tech, in that we had what in my California parlance was an on campus SRI, the Georgia Tech Research Institute, which has been known for many years as the Engineering Experiment Station, which is a body of essentially full-time research performers, plus part-time students, which is chartered to engage in applied R&D, as well as industrial development in the State. It is an integral part of the institute. It comes under my direct responsibility.

A further innovation which we just started a couple of years ago is something we call the Georgia Advanced Technology Development Center, the ATDC. The Governor came to me and to my associates to ask what he could do in his second term to further economic development, particularly in the high technology area. And I was tempted to say first, based on my California experience, to stay out of the way. In Massachusetts, it was the same, because those were spontaneous developments. There was not any intervention by the State government. The Federal Government has a major role in supporting the research in the universities which attracted similar research in industrial organizations, but the State didn't play a role. On the other hand, the question was a good one, if turned, what might be done to add to the spontaneous process? And so we did set up this entity: recruiting—helping in the process of recruiting established industries who were expanding their high technology facilities in the State, any State; helping entrepreneurial startups. Four of my Ph.D. students at Stanford started small

companies there, and I have to readily admit, became millionaires within 5 years.

I saw the process at work, and the first thing they needed was a low-cost space close to the university, where they had access to the libraries, to special instrumentation, to faculty consulting, and so on. The State could help in providing that. Costs in downtown Atlanta are not cheap. So we have on the campus an "incubator" complex of two buildings, and we have staff who are helping in all of this. And I think it's very promising. We're working with about 60 small companies. We are providing housing for some 15 or so at the present time, with a second building under construction.

The question was raised, what are the common principles and the past successes? Well, I have to say that the first one is probably broad gauge sponsors and broad gauge performers. A narrow sponsor in the Federal Government is less likely to help in the whole process than is a more comprehensive one like NASA or DOD, with all due respect to NSF, because I've been on the National Science Board and worked with that organization and believe in it very strongly. Broad gauge performers are better able to help than one with very narrow policies or very narrow outlooks on what universities should or should not do.

Another principle is improved contractual relationships, I keep coming back to that, pioneering being done by ONR, NSF, and others. There is still a present mentality in industry that you have only three basic relationships. One is procurement, another is recruiting, and a third is philanthropy. And not much in between. That's going to change; it will need to.

Finally, I have to give credit once more to Federal initiatives and encouragement that really moved things along in the post-World War II era, and I think that a supporting hand is still going to be very valuable as you continue your efforts to foster the cooperation.

What are the barriers? Well, I think there's still a lack of recognition by industry, parallel to the recognition that the Federal Government adopted in the late 1940's that here were these university people in the universities. They are a national resource. The future of the Nation needs to be enhanced by expediting their research performance. I think by the same token the universities represent a resource for industry, for the industry sector, which, of course, is badly fragmented and looked at corporation by corporation. Factors such as proprietary risks and antitrust legislations hamper their thinking, I believe, in taking a collective view at universities as a collective resource.

We still are lacking good contracting mechanisms between corporations and universities. Typically, very good conversations start at a technical meeting between technical people in the corporation and technical people in the university. They agree that they ought to work together, and some industry money might well be spent at university X. And then things do very well, until it gets into the hands of the legal department and patent department of the corporation. Then the whole thing becomes impossible.

It's easier to support research in-house. A number of things are either in place or being considered that would encourage through tax incentives and regulations on R&D to encourage, maybe even

oblige industry to spend some of its money, to develop the relationship. And then there is a lack of a total delivery mechanism. I mention antitrust only in passing. Lack of a total delivery mechanism, and I think some of the yearning that Congressman George Brown has had for something parallel in the civil sector to what we've had in the DOD, but like NSF: a National Technology Foundation working on that side would somehow accomplish the same results. But there is not a delivery mechanism for the technology transfer into the civil economy as there has been into the military society. That doesn't mean that we can't invent new things.

What about Federal policies? Well, you're well aware of them. The Government does have the power to tax and to regulate. Through taxation, it can generate funds, and those funds have supported various kinds of R&D in the universities. They've done this very well for DOD, and are now beginning to do more in the high tech civil sector. Through tax incentives and tax reductions, if you will, it can stimulate industry to do things cooperatively with us. Several experiments are underway, and I think those need to be continued and strengthened.

Then there is the whole question of antitrust. Industry could be encouraged to do more and some start has been made, as I mention, with MCC, the Microelectronics Computer Corp., with Semiconductor Research Corp., Electric Power Research Institute, and so on.

I think we're going to have to realize that maybe our current economic adversary is not monopoly, but the Japanese, and that we may need to find better ways—I've done some study of that, and I'll comment on that, if you wish.

I think perhaps I should stop at this point. Congressman, and leave it to you to pursue any of these as far as you like.

Representative LUNGREN. Thank you very much. We'll try to get to questions and answers after we've heard from all three panelists and encourage response from all three of you to the questions.

Our next witness is Donald Langenberg. He's the chancellor of the University of Illinois at Chicago, formerly the Deputy Director and Acting Director of the National Science Foundation, and presently chairs the NSF advisory council. He brings a perspective of both private and public universities, as he was a former professor and the vice provost for graduate studies and research at the University of Pennsylvania.

I understand you have a California connection, having received graduate degrees at Stanford and UCLA. You may proceed as you wish.

Mr. LANGENBERG. One small correction, Congressman. Berkeley and UCLA, and as you know, there is a big difference.

Representative LUNGREN. Oh, my heavens. [Laughter.] We must have had a non-California staff person do that.

STATEMENT OF DONALD N. LANGENBERG, CHANCELLOR, UNIVERSITY OF ILLINOIS AT CHICAGO

Mr. LANGENBERG. I have submitted a prepared statement, and I would like to try and summarize some of its major features.

I think in trying to understand the fundamental nature of our universities in order to understand what can be expected of them and what cannot, it is useful to look back into history a bit.

It has been noted that—and I quote:

> Of the 66 institutions that existed in the Western World at the time of the founding of the Lutheran Church in 1530 and still persist in their original form to this day, 62 are universities.

The university is thus one of mankind's most durable and stable institutions, and that is based in part on a resistance to change and the dogged adherence to certain fundamental principles that experience has shown us are of critical importance, not only to the university but to the society it serves.

But that durability and stability are surely also products of flexibility and adaptability. Universities do change in response to societal influences while at the same time trying to preserve the fundamental characteristics that have given them a place among mankind's evidently most fragile yet strongest and toughest institutions.

Universities are a bit paradoxical. They are intensely conservative institutions, and yet they are dedicated to the fostering of radical pursuit, the creation and dissemination of new ideas and new knowledge.

An example that I think is germane to the present discussion of the adaptability of universities began with the Congress' Morrill Act of 1862 and its Hatch Act of 1887. Those induced the creation by the States of a new kind of university, the so-called land grant university, and those universities generally have explicitly articulated missions not only to create new knowledge through research but also to facilitate its use, in the language of the Morrill Act, "for the benefit of agriculture and the mechanic arts."

Those Federal legislative actions for the first time formally established the Federal Government as a partner with academic institutions and private industry in the development of new technology. Among their benefits has been the emergence of American agriculture as a kind of eighth wonder of the world. It is a pillar of national strength, and I believe it is one of our original high tech industries, destined, I might say, increasingly to be even higher tech.

Everyone is familiar with the experience of World War II, which showed us that universities could serve not only as sources of new knowledge and of skilled personnel but could be key resources in meeting a broad range of national needs that went well beyond the agriculture and mechanic arts of the Morrill Act.

Universities have in the years since the war created considerable achievements. They have not done some things. They have not prevented us from experiencing substantial economic difficulties, nor have they assured the continuation of the unchallenged technological and industrial superiority that we enjoyed for so many years following that war.

I think they couldn't have been expected to do so by themselves, but there is nevertheless the question: If high technology is an essential element of the Nation's future and if universities are essential elements of that complex macrosystem that develops high tech-

nology, how can our universities more effectively contribute to the development of technology?

And there is another important question: What can the Federal Government do or perhaps cease doing to help the universities be more effective?

I would like to address a couple of aspects of these questions, beginning with a quotation from George Pake, who is group vice president of the Xerox Corp. In 1983 he delivered the Ferguson lecture at Washington University, and he said, and I quote:

> Inventions of ultimate technological and economic significance once could be made by intelligent, persistent thinkers with little formal higher level education. Edison, the Wright brothers, and Henry Ford come to mind. Modern technological advance is a different story. Consider the transistor, the laser, or synthetic insulin. * * * You don't find these associated with tinkering in a basement or a garage. * * * Thus, the modern R&D enterprise is inextricably linked with the research university, which draws its graduate students from the colleges. There is a great big E that comes before R&D; I shall refer to the E, R&D macrosystem.

I think Mr. Pake makes several important points here. First, there is that great big E. That stands for education, of course. Governments, corporations, and universities don't innovate; people innovate. Governments, universities, and corporations can at best only create conditions that will help individuals create new knowledge and new enterprises rather than impede them.

As Pake notes: intelligence, persistence, and an available basement or garage no longer suffice. Today, higher level edcuation is necessary. At the graduate level, that comes from our research universities, but they, too, are insufficient by themselves. As Pake notes, their students come from the colleges, either their own undergraduate colleges or from other institutions, 4 year or 2 year. More than that, the colleges draw their students from the elementary and secondary school systems. Failure at any level of the E component of the E, R&D macrosystem imperils the ability of the whole to meet the Nation's needs.

I think we all know that in recent years education has once again become a focus of national attention. We have serious problems in our educational system. The responsibilities for solving those problems are distributed throughout our society.

The Federal role, at the lower levels, I think it is generally agreed should be limited to providing leadership, inspiration, and perhaps some funding in carefully targeted areas, but at the upper levels the Federal role becomes more central.

With respect to the issues we are discussing today, I believe that the single most important thing that the Federal Government can do is to support strongly the graduate education and research enterprise in our research universities.

Why? Because, first, that enterprise in the Nation's major source of the fundamental knowledge which is the raw material of the ER&D macrosystem. But also, and I think this is even more important, that enterprise is the sole source of the highly trained people, without which that macrosystem would soon cease to function.

Now, for the Federal Government I think this means not only continuing attention to strong funding but to the nature of that funding, and it also means careful regard for the special needs and character of the research universities as they are affected by Fed-

eral legislation, regulations, and policy. Let me give you several examples.

With respect to the nature of funding, it has become painfully apparent in recent years that the research capabilities for even our leading research universities are suffering from deficiencies in state-of-the-art instrumentation and inadequate physical facilities for research. The Federal research funding agencies have taken steps to ameliorate the instrumentation problem in the last couple of years—I would hasten to say the problem is not solved yet, but it is being worked on—but that facilities problem looms as a major unresolved issue for the Federal Government, the research universities, and their public and private patrons.

With respect to legislation, et cetera, Federal policy in matters of patents, use of human and animal subjects in research, field testing of the products, the new genetic technology, indirect costs—the list goes on and on—all of these strongly affect the university research enterprise.

The current debate about technology transfer to foreign economic and military competitors has profound implications for scientific communication within the research community. That is the issue that commonly goes under the name of export control.

Then there is tax policy. This affects everything from the philanthropic support for university research and education to the conditions under which venture capital may find it favorable or unfavorable to invest in commercialization of the results of university research.

All of this, although it may not seem so, comes under the heading, in my view, of science policy, by which I really mean science and engineering policy, and many of those regulations, laws, policies might seem superficially to be irrelevant to the ER&D enterprise, but I assure that in many cases they are very relevant.

Let me optimistically assume that we will somehow solve the problems in our elementary and secondary school systems and that we will maintain a strong graduate education and research enterprise in our universities. Is that enough to ensure an effective university role in the development of high technology? By no means. No one seems to think we are doing as well as we should or could.

Let me confine myself to making some general observations about the questions which were raised in Chairman Jepsen's letter of invitation to this hearing rather than providing specific answers because I don't think those questions have any simple answers.

One of the observations I would make is that I think there is increasing acceptance of the notion that research universities have a role, a very important role, in technology development. That has been obvious to a lot of us for a long time, but I think its general recognition is relatively recent.

There is increasing acceptance within our universities of the notion that a research university has an obligation to go beyond the training of students and the performance and publication of research and contributing to technological innovation, but this acceptance is not yet general. Our universities are wrestling with a lot of fundamental questions about the extent to which they should or can strengthen their interactions with industry and the private sector generally without risking damage to the fundamental aca-

demic values which are the basis of the stability and durability I referred to earlier.

For those who have concluded they can and should—and there are many of those—there are questions of how and how far. There is some help to be had from that long experience of the land grant universities in agriculture and in the more recent experience of a few universities in Silicon Valley, around Route 128, and the North Carolina Research Triangle, and elsewhere.

But I think the present environment is changing so rapidly, scientifically, technologically, economically, politically, and the research universities are such a diverse lot that I know of no simple guaranteed formula for success which is usable in all circumstances.

Nevertheless, in a quarter century as a university researcher and administrator, and sometimes Federal bureaucrat, never have I seen such intense interest within technology transfer, innovation, and entrepreneurship and such a ferment of ideas about how to do it, nor have I seen such active interest in the States, in State governments, in industry, and in the financial community in becoming involved in partnerships with universities in order to enhance technology transfer.

This last week I attended a conference titled "The Private Sector/University Technology Alliance—Making it Work." The conference was sponsored by the National Council of University Research Administrators, but it brought together nearly 300 people, not only from universities but from State and local governments, large and small industries, venture capital firms, and the Federal Government.

It was evident from that conference that almost literally a thousand flowers are at least being planted if not yet blooming.

Universities are engaged in aggressive exploration with other organizations of a multitude of mechanisms designed to facilitate technology transfer. Many of them are strengthening their traditional patenting and licensing operations and reconsidering their internal policies for faculty and institutional involvement with public and private outside organizations.

Some States are establishing formal statewide and partially State-funded programs to enhance coupling between universities and private industry. An example is the Ben Franklin Partnership in Pennsylvania.

Some industries, singly or through consortia, and some venture capital firms are establishing formal relationships with universities.

Some universities are founding semiautonomous organizations associated with the university to facilitate technology transfer. These are usually not for profit, but in at least one case it is a for-profit entity. Some universities, like my own, are participating in the creation of technology parks, which include incubator facilities and the like.

What might one conclude from all this activity? Well, it seems clear to me that technology transfer and development is an extremely active issue for universities and other institutions, both public and private. A lot of different mechanisms are being actively

explored and established. Many of those will fail. Some may succeed.

This, I think, is a long-term effort from which any payoff is years away. I think it is useful to remind ourselves that Silicon Valley, Route 128, the North Carolina Research Triangle, all initiated at least in party by universities or by their faculty members, are all on the order of 30 years old.

The essential element in all of these efforts is people, individuals with ideas and the resources and the courage to push them to fruition. Entrepreneurs, within or without universities, are rare. We should not assume that every university engineer or scientist is a closet entrepreneur just aching to burst out with a new commercializable idea. They are there, but they are not there in large numbers.

Identification of these entrepreneurs and their support is a fine and relatively undeveloped art. The legal, regulatory, and policy environment in which the ER&D macrosystem must function is extremely important. The difference between facilitation and inhibition can be the difference between success and failure.

To summarize what I believe all this means for the appropriate role of the Federal Government, I would focus on two major items.

First, the Federal Government should maintain a strong and vital graduate education and research enterprise in our universities. Whatever the outcomes of closer relationships between universities and the private sector, they will not include the assumption by the private sector of primary responsibility for support of research in universities. That has been and continues to be a responsibility of the Federal Government and the universities themselves. Without strong research universities, there will be little technology to transfer or develop, nor people who can do it.

Second, I believe the appropriate Federal involvement in the technology transfer process itself might best generally be described as "Stand back and let her rip." But I think we should understand that standing back must be an active, not a passive process. A host of laws, regulations, and policies in areas like tax, antitrust, environmental safety, protection of human and animal research subjects, patents and copyrights, international information exchange, export control, to mention just a few, are required by the public interest. But the long-term public interest in a viable economy and a secure nation can easily be compromised by laws, regulations, and policies which unnecessarily impede the rapid creation, transfer, and development technology.

Congressman, I thank you for your attention.

[The prepared statement of Mr. Langenberg follows:]

Prepared Statement of Donald N. Langenberg

Mr. Chairman, my name is Donald N. Langenberg; I am Chancellor of the University of Illinois at Chicago, one of two campuses of the University of Illinois. It is a privilege to appear before you today to discuss the role of universities in high technology development. I am here on behalf of the National Association of State Universities and Land Grant Colleges, an association representing 145 research-intensive public institutions of higher education. The views I will present, however, are my own and do not necessarily represent official positions of the Association.

In considering the role of universities in technology development, it is important to understand the fundamental nature of our universities, in order to understand what can be expected of them and what cannot. It has been noted that "of the sixty-six institutions that existed in the Western World at the time of the founding of the Lutheran Church in 1530 and still persist in their original form to this day, sixty-two are universities." The university is thus one of mankind's most durable and stable institutions. This durability and stability are in part a consequence of resistance to change, of a dogged adherence to certain

fundamental principles which experience has shown are of critical importance not only to the university but to the society it serves. These include relative freedom from external pressures, political or otherwise, and freedom of intellectual inquiry and scholarly communication. But the university's durability and stability are surely also products of flexibility and adaptability. Our universities do change in response to societal influences, while seeking to preserve the fundamental characteristics which have given them a place among mankind's most fragile, yet strongest and toughest institutions. Paradoxically, universities are intensely conservative institutions dedicated to the fostering of a radical pursuit, the creation and dissemination of new ideas and new knowledge. It is important to understand that the nature of their role in any socially beneficial endeavor, such as the development of high technology, will necessarily be conditioned by this almost schizoid character.

Central to today's subject is an example of the adaptability of the university: The Congress's Morrill Act of 1862 and Hatch Act of 1887 induced the creation by the states of a new kind of university, the so-called "land-grant university", with an explicitly articulated mission to create new knowledge through research and to facilitate its use "for the benefit of agriculture and the mechanic arts." These two Federal legislative actions for the first time formally established the Federal government as a partner with academic institutions and private industry in the development of new technology. Among their benefits has been the emergence of American agriculture as an eighth wonder of the world, a pillar of national strength and one of our original high-tech industries.

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The nation's experience in World War II demonstrated that our universities, as sources of new knowledge and skilled personnel, could be key resources in meeting a broad range of national needs beyond "agriculture and the mechanic arts." The Federal government accordingly embarked on the development of mechanisms for support of research and graduate education in the universities. Enthusiasm for these programs has waxed and waned over the decades since, but, in my view, the Federal government has demonstrated a remarkably consistent and generally strong commitment to the support of research in universities, through administrations of both parties. The result has been the development of a family of research universities which are the envy of the world. They number perhaps a hundred, are located throughout the nation, and are both public and private. With Federal, state, and private support they have given us preeminence in scientific discovery. They have educated most of the men and women who have developed the technologies upon which our nation's security and economy depend, and they have created much of the fundamental knowledge from which those technologies flow. They have <u>not</u> prevented the nation from experiencing serious economic difficulties in recent years, nor have they assured the continuation of the unchallenged technological and industrial superiority which we enjoyed for so many years following World War II. They could not have been expected to do so by themselves, of course, but the question remains: If high technology is an essential element of the nation's future and if universities are essential elements of the complex macrosystem which develops high technology, how can our universities more effectively contribute to the development of technology? Another important question: What can the Federal government do (or cease doing) to help the universities be more effective?

I'd like to begin addressing aspects of these questions by quoting George Pake, Group Vice President of the Xerox Corporation. In his 1983 Ferguson Lecture at Washington University, Dr. Pake said:

> "Inventions of ultimate technological and economic significance once could be made by intelligent, persistent thinkers with little formal higher level education. Edison, the Wright brothers, and Henry Ford come to mind. Modern technological advance is a different story. Consider the transistor, the laser, or synthetic insulin... You don't find these associated with tinkering in a basement or a garage... Thus, the modern R&D enterprise is inextricably linked with the research university, which draws its graduate students from the colleges. There is a great big E that comes before R&D; I shall refer to the E,R&D macrosystem."

Dr. Pake makes several important points here. First, the "great big E that comes before R&D." That, of course, stands for education. Governments, corporations, and universities don't innovate; people innovate! Governments, corporations, and universities can at best only create conditions that will help individuals create new knowledge and new enterprises rather than impede them. And, as Pake notes, intelligence, persistence, and an available basement or garage no longer suffice. Today, substantial higher level education is also necessary. At the graduate level, that is provided by our research universities. But they too are insufficient by themselves. As Pake notes, their students come from the colleges, either their own undergraduate colleges or from other four-year and two-year institutions. Further, the colleges draw their students from

the elementary and secondary school systems. Failure at any level of the E component of the E,R&D macrosystem imperils the ability of the whole to meet the nation's needs.

In recent years, education has once again become a focus of national attention. The problems of our educational system are pervasive, and the responsibility for solving those problems is correspondingly distributed throughout our society. We must provide better and more rigorous academic preparation for our elementary and secondary school students. We face increasing demands for talent of all kinds, but also declining numbers of young people. We must therefore learn how to draw more effectively from underrepresented groups such as women and minorities, and learn how to revitalize the capabilities of our mature citizens. In all this, it seems to be generally accepted that, at the lower levels of the educational system, the Federal government's role should be limited to providing leadership, inspiration, and perhaps funding in carefully targeted areas. At the upper levels, the Federal role becomes more central. With respect to the issues under discussion today, I believe that the single most important thing the Federal government can do is to support strongly the graduate education and research enterprise in our research universities. Why? Because, first, that enterprise is the nation's major source of the fundamental knowledge which is the raw material of the E,R&D macrosystem. But also, and even more important, that enterprise is the sole source of the highly trained people without which the macrosystem would soon cease to function.

For the Federal government, this means not only continuing attention to maintaining funding for research in universities, but careful attention

to the nature of that funding. It also means careful regard for the special character and needs of the research universities as they are affected (often inadvertently) by Federal legislation, regulations, and policies. Let me give several examples.

It has become painfully apparent in recent years that the research capabilities of even our leading research universities are suffering from deficiencies in state-of-the-art instrumentation and inadequate physical facilities for research. The Federal research funding agencies have taken steps to ameliorate the instrumentation problem in the last couple of years, but the facilities problem looms as a major unresolved issue for the Federal government, the research universities, and their public and private patrons.

Federal policy in matters of patents, use of human and animal subjects in biomedical research, use of hazardous materials in research, field testing of the products of the new genetic technology, and indirect costs all strongly affect the university research enterprise, and the list goes on and on. The current debate about technology transfer to foreign economic and military competitors has profound implications for scientific communication within the research community, domestic and international. Then there is tax policy. This affects everything from the philanthropic world's support for university research and education to the conditions under which the venture capital community may find it favorable or unfavorable to invest in commercialization of the results of university research. My point here is that the university's role in the development of high technology is strongly affected, for better or worse, by an

enormous variety of government policies, many of which may appear superficially to be irrelevant. If the research universities are to be effective members of the E,R&D macrosystem, it is essential that relevant Federal policy be developed only with careful attention to its impact on the universities.

Let me now optimistically assume that we will somehow solve the problems in our elementary and secondary school systems and that we will maintain a strong graduate education and research enterprise in our universities. Will that be sufficient to ensure an effective university role in the development of high technology? By no means! There remains the question of how best to transform the products of our universities, people and knowledge, into a vital and competitive economy in a militarily secure nation. Despite past successes, no one seems satisfied that we are doing as well as we could, that the E,R&D macrosystem is functioning as well as it should. To paraphrase Chairman Jepsen's letter of invitation to this hearing: What are successful modes of technology transfer from universities to industry? Are there principles common to such successes? What Federal policies would promote more rapid technology transfer? What barriers to more efficient transfer should be addressed by Federal policy?

I believe I can best serve the purposes of the Committee by making some general observations rather than by trying to answer these questions specifically, for I do not believe they have simple answers. First, I think it is now widely agreed that our research universities have a role, a very important role, in the development of technology. This has been obvious to many for a long time, but I believe its general recognition and acceptance is of recent vintage. There is increasing acceptance

within our universities of the notion that a research university has an obligation to go beyond the training of students and the performance and publication of research in contributing to technological innovation, but this acceptance is not yet general. Our research universities are wrestling with many fundamental questions about the extent to which they should or can strengthen their interactions across the interface with industry and the private sector generally, without risking damage to the fundamental academic values which are the basis of the stability and durability to which I referred earlier. For those which have concluded they should and can, and there are many, there are questions of how, and how far. There is some help to be had from the long experience of the land-grant universities in agriculture, and in the more recent experiences of a few universities in such places as Silicon Valley, Route 128, and the North Carolina Research Triangle. But the present environment is changing so rapidly, scientifically, technologically, economically, and politically, and the research universities are such a diverse lot, that I know of no university which could confidently present a guaranteed formula for success, usable in all circumstances. Nevertheless, never in a quarter century as a university researcher and administrator have I seen such intense interest among the university research community in addressing the issues of technology transfer, innovation, and entrepreneurship, such a ferment of ideas about how to do it, as today. Nor have I seen such active interest in the states, in industry, and in the financial community in becoming involved in partnerships with universities in order to enhance technology transfer.

Just last week I attended a conference on the subject, "The Private

Sector/University Technology Alliance - Making It Work." The conference was sponsored by the National Council of University Research Administrators and brought together nearly three hundred people from universities, state and local governments, large and small industries, venture capital firms, and the Federal government. It was evident from the conference discussions that almost literally a thousand flowers are being planted, if not yet blooming. Universities are engaged in aggressive exploration with other organizations of a multitude of mechanisms designed to facilitate technology transfer. Many are strengthening their traditional patenting and licensing operations, and reconsidering their internal policies for faculty and institutional involvement with public and private outside organizations. Some states are establishing formal state-wide and state-funded programs to enhance coupling between universities and private industry, like the Ben Franklin Partnership in Pennsylvania. Some industries, singly or through consortia, and some venture capital firms are establishing formal relationships with universities. Some universities are founding semi-autonomous organizations to facilitate technology transfer, usually not-for-profit but, in at least one case, for-profit. Some universities, like my own, are participating in the creation of technology parks.

What might one conclude from all this? It seems clear that technology transfer and development is an extremely active issue for universities and other institutions, both public and private. Many different mechanisms are being actively explored and established. Many will fail, some may succeed. This is a long-term effort from which any pay-off is years away. (It is useful to remember that Silicon Valley, Route 128, and the North Carolina Research Triangle, all initiated at least in part

by universities or their faculty members, are all on the order of thirty years old.) The essential element in any such effort is people, individuals with ideas and the resources and courage to push them to fruition. Entrepreneurs, within or without universities, are rare. Their identification and support is a fine and relatively undeveloped art. The legal, regulatory, and policy environment in which the E,R&D macrosystem must function is extremely important. The difference between facilitation and inhibition can be the difference between success and failure.

To summarize what I believe all this means for the appropriate role of the Federal government, I would focus on two major items:

- The Federal government should maintain a strong and vital graduate education and research enterprise in our universities. Whatever the outcomes of closer relationships between universities and the private sector, they will not include the assumption by the private sector of primary responsibility for support of research in universities. That has been and should continue to be a responsibility of the Federal government and the universities themselves. Without strong research universities, there will be little technology to transfer or develop, nor people who can do it.

- The appropriate Federal involvement in the technology transfer process itself might best be described as "Stand back and let 'er rip!" But we should understand that standing back must be an active, not a passive process. A host of laws, regulations, and policies in areas like tax, anti-trust, environmental safety, protection of human and

animal research subjects, patents and copyrights, and international information exchange, to mention just a few, are required by the public interest. But the long-term public interest in a viable economy and a secure nation can easily be compromised by laws, regulations, and policies which unnecessarily impede the rapid creation, transfer, and development of technology.

Mr. Chairman and members of the Committee, I thank you for your attention.

Representative LUNGREN. Thank you very much for that testimony. I certainly appreciate it.

The next panelist we have is John Kotula, president of the Delaware Technical and Community College, giving us a different perspective, but just as important a perspective on this whole question.

Mr. Kotula, interestingly enough, played professional major league baseball for approximately 2 years before becoming a high school counselor and sports coach, later joined the Delaware Technical and Community College as assistant to the president, later becoming the vice president and then the president.

We welcome your testimony.

STATEMENT OF JOHN P. KOTULA, PRESIDENT, DELAWARE TECHNICAL AND COMMUNITY COLLEGE, DOVER

Mr. KOTULA. Thank you very much, Congressman. Ladies and gentleman, it is indeed an honor and a pleasure to appear before you today to talk about transfer of technology and also to talk about community colleges. I'm going to vary from my prepared statement. I came down on the Metroliner this morning from Wilmington, read the prepared statement and decided perhaps I needed to add some additional comments.

It's really an honor to represent community colleges. And I think we're the best kept secret perhaps in higher education in the United States today. I say that, I'll give you some facts.

In the United States, we have 1,219 2-year colleges throughout the country. Last year, in 1983-84, we enrolled 9.3 million students in credit and noncredit courses. This year, this fall, approximately 55 percent of all students entering institutions of higher education for the first time will enroll in community colleges.

I think one of the nicest things about community colleges is that they're within easy commuting distance of residences of people throughout the country. Most people think that the average age of a community college student is 18 or 19 years of age, but that is not true, particularly not in Delaware. The average age of a student at Delaware Technical and Community College last year was 27.5 years.

We do emphasize the technical aspect within a community college system as such. The placement rate of our graduates entering the world of work is about 85 percent. Of the group that are employed, 90 percent of the graduates are employed in Delaware and 95 percent of the graduates are employed in fields for which they were trained.

The question, then, before us today is, how can community colleges be helpful in the transfer of technology? The transfer of technology means many things to people in the community college sector—certainly not research, because most community colleges are not involved in research.

The topic of transfer of technology then is, how do we transfer technology from Government to industry, from Government to education, from education to industry, and from industry to education?

An example of this—I talked to our associates at AACJC, the American Association of Community and Junior Colleges; they informed me that there are 700 Federal or federally contracted labs doing research in the United States. Community Colleges can be a vital link in disseminating research done at these Federal labs, particularly to small businesses. That appears to be a problem in dissemination and transfer of technology. Community Colleges that are worth their salt at all, certainly are very active with the business and industrial community. They're active through local advisory committees.

We have four campuses in Delaware. On those four campuses, we have 65 advisory committees to advise us as to curriculum, and as to needed technologies in the State of Delaware. We have 700 people from business and industry who work with us and advise us. These people, also on the advisory committee, help us obtain adjunct faculty, help us obtain equipment, help us recruit students, and of course, after students finish programs, employ the students. They also provide opportunities for college staff residencies in industry, the transfer of technology from the industry to the institution and from the institution to industry.

Certainly, last but not least, the advisory committees enable us to have on-site training opportunities for particularly smaller businesses and industries in the State of Delaware.

We feel, in the community college sector, that there must be better linkages between education and business and industry if we are going to transfer technology properly and quickly.

Let me give you an example. We've heard about the plight of the automobile industry. The automobile industry is moving now to an automated manufacturing situation, robotics, if you will. In Delaware, we've worked very closely with the General Motors plant. They are transferring from building Chevettes to Oldsmobiles. Over the next 3 or 4 years, our community college system will be working with the automobile industry, and particularly GM—we also have a Chrysler plant—in providing over 800,000 hours of training. What type of training? Well, if you're moving to an automated system, certainly, electronics, developmental work, and developmental or remedial work for workers is needed because they're going to have to change in the job that they're doing.

Scott Paper. We had a project involving Scott Paper in Dover, DE, where we transferred an entire assembly line from Ohio to Dover, DE. This is transfer of technology in its purest form.

When you hear of Delaware, you think of the DuPont Co. The DuPont Co. is, of course, one of the top research companies in the world, but even the DuPont Co. needs assistance. We, at the present time and over the last 3 years, have been working with the DuPont Co. in retraining 1,100 chemical technicians.

Community colleges can be an important cog in retraining projects everywhere. In Delaware, for the last 4 years, the State General Assembly passed the Financial Center Development Act. We have 14 new banks in Delaware. We have worked with the great majority of those banks in training, not only technicians, but also in assisting in short-term training programs for data entry people, word processing, and so on.

A second linkage, to show that education and business and industry can work effectively together, we have developed in Delaware, a fire protection burn lab facility. That probably doesn't mean much to you. It's the only facility of its type in the United States of America. The State financed $125,000 for the project. Business and industry contributed over $1 million worth of equipment for that lab.

We are training safety technicians and providing safety training for people within industry, for industries not just from Delaware but from industries all over the United States.

That's an example of how linkages between business and industry can work effectively in providing training, in transferring technology within industry and also providing jobs, new jobs.

Third, we hear of the plight of the steel industry. What is going to happen to the steel industry? In my opinion, the steel industry is going to make it. The important question is, how long is it going to take the steel industry to make it? There certainly must be a transfer of technology within the steel industry. We know that computers must be involved. We know that electronics must be involved.

Community colleges can help with that. Certainly, the steel industry is going to need some help from the Federal Government, but this is a problem that needs to be addressed by the Government, by States, and certainly by community colleges and education, in general.

Another example of a problem that we face right now: We lost a major corporation in Delaware a few years ago, because we didn't have enough tool-and-die makers and also not enough trained machinists. That is a national problem. We don't see anything being done about it. Most of the tool-and-die makers and most of the machinists that have been trained in this country were trained around the shipbuilding industry in World War II, in the 1940's, and around the aircraft industry.

What's happening now, most of those people are retiring. We have a shortage. It's my understanding that even some defense contracts for the Department of Defense, cannot be met within this country, because of the shortage of tool-and-die makers. Certainly, this is an example of where the Federal Government can come forward and provide opportunities in training in the transfer of technology.

Last, but certainly not least, we have a project in Delaware known as the Institute for the Study of Advancing Technology funded by the Department of Commerce. We've been funded for 2 years now. What we are trying to do is to identify technologies, so that we can cut down the lag time between when industry needs technicians and when educational institutions can provide technicians. In the past, we certainly have not been able to provide technicians as rapidly as we need to. An example is the whole computer field and the electronics industry. We have a shortage of electronics technicians right now in the United States that will run through 1988.

What we are trying to do with the Institute for the Study of Advancing Technology is to cut the lag time between the identification of the need for a program and the delivery of the program. An example of this is our first year of operation we developed a 2-year program in automated manufacturing technology, robotics, which we disseminated through five other community colleges throughout the United States.

This year we're developing a 2-year program in genetic engineering which we will be disseminating nationally through 16 community colleges.

We need some help in the community college sector and in the general education area in order to have quicker startup of 2-year programs in education.

Let me conclude by commending the Joint Economic Committee on looking at this problem that faces all of us, the transfer of technology. It is certainly a topic that has the concern of community college educators throughout the United States, and we commend the committee for looking at this problem.

Thank you, Congressman.

[The prepared statement of Mr. Kotula follows:]

Prepared Statement of John R. Kotula

WHEN TECHNOLOGY TRANSFER IS TO BE IMPLEMENTED, A VITAL FACTOR TO BE ADDRESSED IS THE EXISTENCE OF AN ADEQUATELY TRAINED LABOR FORCE.

MUCH EMPHASIS HAS BEEN PLACED ON THE SHORTAGE OF GRADUATE ENGINEERS, PHYSICISTS AND OTHER SCIENTISTS TO MEET THE NEEDS OF THE FUTURE. ONCE THE RESEARCH AND DEVELOPMENT HAS BEEN COMPLETED, IT IS UP TO THE MANUFACTURING SECTOR TO PROVIDE THE MANPOWER AND FINANCIAL RESOURCES TO DELIVER THE PRODUCT TO THE MARKETPLACE.

PAST EXPERIENCE IN THE AREAS OF MICRO-ELECTRONICS, ENGINEERING, LASER OPTICS, AND COMMUNICATIONS HAS SHOWN THAT A VITAL LINK IN THE TRANSFER OF TECHNOLOGY FROM RESEARCH AND DEVELOPMENT LABORATORIES TO THE MARKETPLACE, IS A WELL-TRAINED TECHNICIAN. COMMUNITY COLLEGES ACROSS THE COUNTRY HAVE SUCCESSFULLY PRODUCED SUCH TECHNICIANS FOR THE PAST TWENTY YEARS.

THERE ARE 1,219 TWO-YEAR COLLEGES IN THE UNITED STATES WHERE APPROXIMATELY 9.3 MILLION STUDENTS WERE ENROLLED IN CREDIT AND NON-CREDIT COURSES IN 1983. FIFTY-FIVE PER CENT OF ALL ENTERING FRESHMEN IN POSTSECONDARY INSTITUTIONS, ENROLL IN COMMUNITY COLLEGES.

AS TECHNOLOGICAL ADVANCEMENTS ARE IMPLEMENTED IN THE WORKPLACE, MANY EXPERTS PREDICT THAT THE ENTIRE LABOR FORCE OF THE UNITED STATES WILL NEED TO BE RETRAINED EVERY TWENTY YEARS. OBVIOUSLY THE WORKING PROFESSIONALS EXPECT TO BE EMPLOYED FOR AT LEAST THIS LENGTH OF TIME.

THE ISSUE BECOMES THEN, HOW EXISTING LABOR FORCES, WILL BE TRANSFERRED TO OTHER SECTORS OF THE ECONOMY OR INTO NEWLY DEVELOPING TECHNOLOGIES. AN EXAMPLE OF THIS PROBLEM IS THE CURRENT PLIGHT OF STEEL AND AUTOMOTIVE WORKERS ACROSS THE COUNTRY. THE COMMUNITY COLLEGE SYSTEM IS IDEALLY SUITED TO ASSIST IN ADDRESSING THIS ISSUE AND IS, IN FACT, ALREADY ACTIVELY INVOLVED IN THE RETRAINING EFFORT IN MANY PARTS OF THE COUNTRY.

AS PRESIDENT OF DELAWARE TECHNICAL AND COMMUNITY COLLEGE, I WOULD LIKE TO ADDRESS THE FOLLOWING FOUR ISSUES THAT I BELIEVE AFFECT TECHNOLOGY TRANSFER.

I. IDENTIFYING SUCCESSFUL MODES OF TECHNOLOGY TRANSFER

AN IMPORTANT MEANS OF TECHNOLOGY TRANSFER IN COMMUNITY COLLEGES IS THE CLOSE ASSOCIATION WITH LOCAL EMPLOYERS. THIS ASSOCIATION LEADS TO A STRONG LINKAGE BETWEEN EDUCATION AND INDUSTRY WHICH IS MANIFESTED IN A VARIETY OF WAYS. IN OUR COLLEGE ALONE, SIXTY-FIVE PROGRAMS UTILIZE ADVISORY COMMITTEES COMPOSED OF BUSINESS AND INDUSTRIAL REPRESENTATIVES. THE INPUT OBTAINED FROM THESE ADVISORY COMMITTEES PLAYS A MAJOR ROLE IN CONSTANTLY UPGRADING TECHNICAL CURRICULA WHICH WILL LEAD TO THE PRODUCTION OF QUALIFIED TECHNICIANS. OTHER SUCCESSFUL METHODS USED TO TRANSFER TECHNOLOGY ARE:

1. USE OF INDUSTRIAL PERSONNEL AS ADJUNCT FACULTY.

2. COLLEGE STAFF RESIDENCIES IN INDUSTRY AS PART OF ON-GOING STAFF DEVELOPMENT FOR TEACHING PROFESSIONALS.

3. ON-SITE TRAINING FOR INDUSTRY CONDUCTED BY COLLEGE STAFF. AN EXAMPLE IS THE USE OF OUR COLLEGE FACULTY TO TRAIN EMPLOYEES FOR NEW AND EXPANDING INDUSTRIES IN THE STATE OF DELAWARE. THIS INCLUDES TRAINING OF SPECIALIZED WELDERS, BANK PROCESS OPERATORS, AUTO WORKERS, AND PERSONNEL IN THE CHEMICAL INDUSTRY. ACTIVITY OF THIS NATURE GENERATES A DIALOGUE BETWEEN INDUSTRY AND EDUCATION AS WELL AS REVENUE TO SUPPORT COLLEGE OPERATIONS.

4. A JOINT VENTURE BETWEEN EDUCATION AND INDUSTRY HAS RESULTED IN EQUIPMENT ACQUISITION AND SHARING OF PERSONNEL. AN EXAMPLE IS THE CONSTRUCTION AND OPERATION OF THE ONLY FIRE PROTECTION FACILITY AVAILABLE IN THE PUBLIC SECTOR IN THE UNITED STATES.

ANOTHER MODE OF TECHNOLOGY TRANSFER USED BY COMMUNITY COLLEGES IS THE UPGRADING OF COLLEGE PROFESSIONALS BY ATTENDING GRADUATE COURSES IN NEARBY UNIVERSITIES OR BY ATTENDING SPECIALIZED REFRESHER COURSES, WORKSHOPS, OR SEMINARS CONDUCTED BY PROFESSIONAL ORGANIZATIONS.

II. PRINCIPLES COMMON TO THE SUCCESSFUL TRANSFER OF TECHNOLOGY

SOME FACTORS COMMON TO THE SUCCESSFUL TRANSFER OF TECHNOLOGY INCLUDE:

1. AN OPEN DIALOGUE BETWEEN INDUSTRY AND EDUCATORS

AN EXAMPLE WOULD BE DELAWARE TECHNICAL AND COMMUNITY COLLEGE'S INVOLVEMENT WITH THE RESEARCH DIVISION OF THE DUPONT COMPANY IN ASSISTING THE COMPANY IN PREPARING A FIVE YEAR ON-THE-JOB TRAINING PROGRAM FOR APPROXIMATELY 1,100 TECHNICIANS. COLLEGE PERSONNEL AND COMPANY STAFF WORKED JOINTLY IN A VENTURE THAT HELPED THE COMPANY OBTAIN A QUALITY EDUCATIONAL PROGRAM AND THE COLLEGE PROFESSIONALS INVOLVED GAINED A BROADER PERSPECTIVE OF INDUSTRY'S NEEDS.

2. Quick Response by the Educational Sector to Industrial Needs

In the previous example, the College responded to industry's request in less than two weeks and assisted the company with the development of a program in which our College was involved for approximately five years. This type of responsible cooperation has resulted in the development of training programs in Delaware for General Motors, various financial institutions, and several other manufacturing plants.

3. Qualified Teaching Staff

No successful educational program has ever been conducted without qualified teaching personnel.

4. An Available Market for the Placement of Graduates

Only those programs which are developed in response to local industrial needs will result in technical graduates being placed in their special fields of interest. Delaware Technical and Community College's placement ratio is approximately 85%.

III. FEDERAL POLICIES THAT PROMOTE RAPID TECHNOLOGY TRANSFER

THE FEDERAL GOVERNMENT CAN ASSIST THE COMMUNITY COLLEGE BY PROVIDING ADEQUATE FUNDING TO PROMOTE THE FOLLOWING ACTIVITIES:

1. STAFF DEVELOPMENT
2. NEW PROGRAM DEVELOPMENT
3. NEW EQUIPMENT ACQUISITION

AN EXAMPLE OF FEDERAL POLICY WHICH HAS ALLOWED US TO BRING NEW TECHNOLOGY INTO OUR COLLEGE, IS THE USE OF FUNDS FROM THE ECONOMIC DEVELOPMENT ADMINISTRATION OF THE U.S. DEPARTMENT OF COMMERCE AND THE U.S. DEPARTMENT OF EDUCATION. AN AUTOMATED MANUFACTURING CURRICULUM AND A BIO-SCIENCE CURRICULUM WERE DEVELOPED UNDER A GRANT FROM THE U.S. DEPARTMENT OF COMMERCE. EQUIPMENT AND SUPPORT PERSONNEL WERE OBTAINED UNDER A GRANT FROM THE U.S. DEPARTMENT OF EDUCATION. UNDER THE SAME GRANT FROM THE U.S. DEPARTMENT OF COMMERCE, DELAWARE TECHNICAL AND COMMUNITY COLLEGE WAS ALSO ABLE TO CREATE THE INSTITUTE FOR THE STUDY OF ADVANCING TECHNOLOGY.

THE INSTITUTE WAS FOUNDED IN 1981 FOR THE PURPOSE OF IDENTIFYING EMERGING TECHNOLOGIES AND DEVELOPING APPROPRIATE CURRICULA. UNDER THE AUSPICES OF THE INSTITUTE, A

PARTNERSHIP HAS BEEN ESTABLISHED AMONG SIXTEEN TWO-YEAR COLLEGES LOCATED IN VARIOUS AREAS OF THE COUNTRY.

IV. BARRIERS TO TECHNOLOGY TRANSFER THAT GOVERNMENT SHOULD ADDRESS

1. IT HAS BECOME NECESSARY FOR COLLEGES AND UNIVERSITIES TO DEVOTE MUCH TIME TO DEVELOPMENTAL PROGRAMS FOR THOSE STUDENTS WHO ARE UNABLE TO ENTER POSTSECONDARY COURSES OF STUDY.

2. A TIME LAG EXISTS BETWEEN THE NEED FOR TRAINED TECHNICIANS AND THEIR AVAILABILITY FROM EDUCATIONAL INSTITUTIONS. AN EXAMPLE OF THIS TIME DELAY IS IN THE FIELD OF COMPUTERS AND DATA PROCESSING. WHEN TECHNOLOGICAL CHANGES IN THE LATE 60'S AND EARLY 70'S MADE THE COMPUTER A NECESSARY TOOL IN MOST SEGMENTS OF BUSINESS AND INDUSTRY, THE PERSONNEL TRAINED IN THE USE AND REPAIR OF THIS EQUIPMENT WERE NOT AVAILABLE. EDUCATIONAL INSTITUTIONS REQUIRED FROM THREE TO FIVE YEARS TO DEVELOP CURRICULA AND PRODUCE GRADUATES FOR THAT MARKET. IT HAS TAKEN ALMOST A DECADE TO TRAIN THE NUMBER OF TECHNICIANS REQUIRED TO FILL THIS VOID.

3. DISSEMINATION OF INFORMATION FROM INDUSTRIAL AND GOVERNMENT RESEARCH AND DEVELOPMENT, PERTINENT TO THE

BUSINESS AND EDUCATIONAL COMMUNITIES, APPEARS TO BE UNDULY LIMITED.

4. THERE IS A LACK OF TIMELY RESPONSE BY SOME EDUCATORS TO TECHNOLOGICAL NEEDS. AN EXAMPLE OF THIS PROBLEM IN THE UNITED STATES TODAY, IS THE CRITICAL SHORTAGE OF TRAINED TOOL AND DIE MAKERS FOR OUR INDUSTRIES. FOR MANY YEARS, LITTLE ATTENTION WAS GIVEN TO THAT FIELD UNTIL ALL THE AVAILABLE TOOL AND DIE MAKERS TRAINED IN THE EARLY FORTIES BEGAN TO RETIRE.

THIS IS A VERY BRIEF SYNOPSIS OF SOME OF THE ISSUES RELATING TO TRANSFER OF TECHNOLOGY AS SEEN IN THE COMMUNITY COLLEGE SYSTEM IN THE STATE OF DELAWARE. THE WHOLE AREA OF THE TRANSFER OF TECHNOLOGY, HOWEVER, IS A MATTER OF CONCERN TO COMMUNITY COLLEGE EDUCATORS THROUGHOUT THE COUNTRY.

IT IS ENCOURAGING TO SEE THAT THE JOINT ECONOMIC COMMITTEE IS ADDRESSING THIS IMPORTANT NATIONAL PROBLEM.

Representative LUNGREN. Thank you very much.

Three different perspectives on a very important question.

Let me just ask this one. I'm not sure quite what the answer should be or is, and that is, we have looked into the question of the Government labs that exist in the United States, and one of the disappointing things we have found is that even though they are attempting to try and disseminate information and ideas that may be spun off into the private sector, the response from the private sector has not been very good thus far.

The thing I keep coming back to is that the center that we've established for that information to get out, the National Technical Information Service, is utilized first and foremost by Mitsubishi, and most of us here in the Congress don't even know they exist, that information mechanism.

Is there a place for the Government labs working with the universities in joint action for utilizing the information that exists in the Government labs to be either refined further for research purposes or to be utilized by the universities as part of the mechanism for making it commercially viable?

Mr. LANGENBERG. Let me try a couple of comments on that. I think the answer is, yes, there is a place.

One of the problems that I think is the limiting element in university-industry cooperation is coupling. If you look at a university, you see something perhaps a little bit similar to what you see when you look at the U.S. Government. It's a very large, complex operation. And if you are an entrepreneur, you have money to invest, it is not simple to look within a given university and discover whether there is a faculty member with an idea, whether there is a project with commercializable potential.

There needs to be some kind of coupling mechanism. And I think that's what universities are really seeking to develop now. I think we are not seeking to develop so much a strong research capability. We have that. We want to maintain that. We're looking for coupling mechanisms. I think the national labs have much of the same problem. They have been, like so many universities over the past decade or two, inclined to tend to their own knitting, to ignore strong interactions with the outside, even with universities, for that matter, and just simply try and get the job done. Those coupling mechanisms really aren't there. But I see the National Laboratories beginning, finally, more or less actively and with some prodding from DOE central management, to begin to establish those relationships. There are, I think, some model relationships between the Oak Ridge National Laboratory and the University of Tennessee, for example. And the other national labs are beginning. It's beginning to happen, but it's a long, slow process.

Representative LUNGREN. Mr. Pettit.

Mr. PETTIT. Well, I wouldn't add too much to that. I think that there are mechanisms, and the best ones, I would say, are not institutional mechanisms, but professional communication among people working in the same business through the society meetings and also through symposia of all kinds. Those do exist. I can't help observing that some of the national labs, of course, are under the auspices of a university, like the Jet Propulsion Lab at Cal Tech. My observation is that the communication between the two parts

of the same overall institution over here is not automatic, not even there, unless there's a common, highly focused, technical interest.

Those avenues are open, and I think we can keep them open. The most immediate threat, probably, is this question of sensitive information in the nonclassified sector, and in clamping down on that. So much of the work in Government laboratories, whether in universities or otherwise, is focused on particular missions. The highly security-conscious people in town here don't like to even talk about this, as much as they were willing to in the past.

Representative LUNGREN. That obviously is one problem, but it just struck me that when Mitsubishi is availing itself of the information that is out there, and somehow, maybe some U.S. concern running a distant second, there is some problem in linkage there.

Mr. Kotula, your statement that community colleges could serve a purpose is an interesting one, because in talking to small business or representatives of small business, venture capitalists in two parts of the country, they indicated that there may be information in the Government labs that would be of interest to them, but they don't have a mechanism by which they can find out. And one of them said, simply, if there were a facility in our area where we could get that information through a system that was linked by computers rather than having to write back to the center and getting that information, it might be far more available to us and something we might use.

And you made an interesting comment about the community colleges might serve a purpose in part of that process.

Mr. KOTULA. We see, Congressman, as a problem, the dissemination of information to small businesses. I think universities and community colleges—community colleges can help because their close to everyone, and work together. As a matter of fact, I believe our association has a proposal here in Washington to do just that.

Representative LUNGREN. There was a comment made by both President Pettit and Chancellor Langenberg about the "incubator" facilities. Perhaps I didn't raise the issue very articulately, but I mentioned that possibility when I had a panel of both a group of entrepreneurs and a group of venture capitalists up in the Route 128 2 weeks ago. I mentioned the "incubator" facility-type approach, and they didn't seem to think—first of all, they hadn't heard too much about it, and second, they didn't think it was such a good idea. As one fellow said to me: "I tried to get away from 'big brother' or a big company and start on my own, and I don't want to get involved with some sort of overall process that somebody has developed."

I think they may have had a wrong idea about it.

Just from your observation, what is the importance of the "incubator"-type facility for the transfer of technology? Do we have a track record on it? Has it worked some places? Is it briefly described as an attempt to create an infrastructure that perhaps was developed in some other areas? How do we discuss that issue?

Mr. PETTIT. Well, I would say it was simply something that can be added to whatever else is already in place. It isn't necessary. It was done in the Stanford area without it.

Of course, one has to recognize that the Silicon Valley, the Stanford area, got going in quite a different economic and technological

time, which you can't replicate just by deciding you are going to. This was in the 1950's when there was a burgeoning economy, when there was a cold war and a high technology defense, when the manned space program was just getting ready to take off, and a shortage of engineering graduates for the expanding industry. There were all kinds of factors, and land and building costs were still low around Palo Alto. You could rent office space quite cheaply. It is not true in Atlanta; it is not true in other places.

So I think it is a useful addition, and I guess the testimony is that over the last year we have had small entrepreneurs standing in line to rent our space to be close to the campus and get the benefits thereof.

I would say there was a potential Federal role which you have operated right in the midst of our getting this thing going. We sought to finance the building through a three-way financing—one-third Federal, one-third State, and one-third private sector. And you could go to each one of them and offer the great straight leverage, three to one. But the Economic Development Administration folded up at an unfortunate time. The State did step in and provide the extra one-third.

I don't favor the Federal Government having large-scale handouts, but if you can offer this kind of multiplier and stimulant, it might be a good thing to do with Federal money. You can't do everything everywhere, of course.

I think it is a real plus. I feel it in our area, which there is a process underway of high technology development. We have a lot of the ingredients. We have tremendous communication to the outside world, and we have got a reasonable climate. We have cultural facilities, and so on. There has been a shortage of venture capital, but that is pretty portable, and it is coming in quite strongly.

So what can you add in this picture? The incubator is useful there. There is a misunderstanding that research parks and incubators are going to do everything for everybody. In fact, in the Stanford area it was quite the opposite. The Stanford Industrial Park that the university started was a high rent district. It was for a company to graduate into after it had 4 or 5 years of earnings at the $5 million level and above.

I remember when Mr. Terman retired in 1965 I gave a talk. I did some research, and most of the industrial or research parks at that time were easily classed as failures, with less than 10 percent occupancy. And the Stanford Park was very good, but it already had this tremendous surrounding area feeding tenants into it.

I think it is a useful thing. It is no cure-all.

Representative LUNGREN. Is there any reason why, when you did the research 10 or 12 years ago, they were not very successful and now they appear to be successful? Has there been a different approach utilized?

Mr. PETTIT. No, no, I think the ones that are successful now were successful then, too. A lot of the ingredients were missing. This environment, some of the out-of-the-way places were hard to get to, and such things were a real obstacle. I think the Research Triangle Park has done very well in spite of lacking some of these things.

Representative LUNGREN. Mr. Langenberg.

Mr. LANGENBERG. From my point of view, it seems to me that an incubator facility is not something that is a candidate for venture capital support, not something that would be attractive in and of itself to a venture capitalist, but it is rather a place to look for ventures to fund in the next phase. It is, again, a coupling mechanism between the university, within which the kind of work that would go on in an incubator facility is inappropriate and a stage that I might term a real startup company; that is to say, something which rests on a strong enough base of demonstrated technological achievement that it deserves venture capital funding to turn it into a real commerical enterprise. And there has been something missing in between, and it is that niche that I think the incubator facilities will fund.

It is a little too early, I think, to say that indeed they are successful now. Most of the ones that I am aware of are really too new to be sure. We in Chicago are optimistic about ours, but I couldn't prove to you that it is a success. It hasn't been built yet.

Representative LUNGREN. How is yours to be funded?

Mr. LANGENBERG. State appropriations.

Representative LUNGREN. I understand, Mr. Pettit, about your chagrin at not having the one-third at just the time you are looking for it from the Federal Government. I just wondered, since we are trying to establish what exactly our priorities are and what are the most important or primary things that we ought to be funding, whether the incubator type approach, if it works in a number of different areas, would provide enough pay-off, so to speak, in the local and State area that the States would be encouraged to do that funding.

Mr. PETTIT. Well, we think so, and we think you can show employment generation, which is a good flag to fly in front of the State legislature, not only during the time they are actually in the incubator space but when they evolve out and are growing. There are going to be a lot of problems that we haven't faced yet; namely, how to kick somebody out when they are doing well and want to stay but should not. Our incubator is a little nice. I am afraid they are going to want to stay.

Representative LUNGREN. Well, if we cut the funds out, they won't be any nicer then. [Laughter.]

Mr. LANGENBERG. It might be worth mentioning here a Federal role at the incubator level that I suspect may turn out to be very important, and that is the—those are the consequences of the Small Business Innovation Act, the Small Business Innovation Research programs that have been established in the various research funding agencies as a result of that act.

As you probably know, the universities opposed that act when it was proposed. I was at NSF at the time, and although NSF ultimately supported it there were a good many questions and uncertainties in NSF's mind about it at the time.

We are finding in Chicago—I might just add that although we don't have our incubator facility functioning, we have in fact eggs being incubated in the form—to name one example, a biotech firm, which is living in an old church, an old A-frame church on the property, at the moment and is doing very well with first- and second-phase SBIR awards from NIH. These are turning out to be

exceedingly useful in helping that company get to the point where it can begin to absorb venture capital, and it appears to be moving toward that point and very rapidly with SBIR Federal support.

Representative LUNGREN. Mr. Kotula, you have indicated in your testimony a rather close relationship between the community colleges and industry in Delaware, and both Mr. Langenberg and Mr. Pettit have indicated that they see that coming together more closely on the university level, but recognize the unique characteristics of the university system, the permanence and the difficulty in making those institutions change, and that being a good part as well.

The community college serves a slightly different function than the 4-year institutions, as you have indicated. You indicate that the Delaware experience has been a rather good one between industry and community colleges.

Do you see any reason why that type of experience could not be duplicated in other States across the country, and does that necessarily require some Federal participation if in fact you think that should be done?

Mr. KOTULA. Yes; let me say that the Delaware experience has been very positive because when the community college system was established in 1967 by the Governor and the general assembly it was set up to serve business and industry, and as such that has been our mission and always will be our mission.

I think this is also being done in other States. I can't say that it is being done in all States. I think incentives from the Federal Government would enhance the opportunity for community colleges to better serve business and industry, and again it is a matter of mission. Our mission is to serve business and industry in Delaware.

Representative LUNGREN. Let me ask you this question because I think it was something that we had hoped would occur, and that was when we replaced the CETA Program with the Job Partnership Training Act one of our hopes was a closer connection between industry, which is the provider of the jobs, with those institutions that we use to train the people for the jobs, including the community colleges.

My feeling has always been that the worst thing you can do to someone who is unemployed is to give them false hope by training them for a job that doesn't exist.

Along with a lot of other changes that we put into the Job Partnership Act on a bipartisan basis, we had hoped that this close coordination would take place.

Can you tell me whether your institution is involved in the Job Partnership Training Act and the way it is applied in Delaware and whether that act has been a useful mechanism to expand the effectiveness of the community college system from a Federal funding standpoint?

Mr. KOTULA. In Delaware we are the major contractor for JTPA programs. I think, generally speaking, that is true throughout the country. The program, I think, has been successful. We would like to see, Congressman, more money in the act for industrial training to help smaller businesses expand.

From our perspective, though, the program is successful. People are getting jobs. It also appears to be improving on the CETA Program.

Representative LUNGREN. One of the things we found out, as you may know, is that in CETA, I think it was 18 or 20 cents out of every dollar actually went to train somebody. We now require by statute that 70 cents out of every dollar go for training.

It is awfully easy up here to say, boom, 70 cents of every dollar is going to do it, using the legislative fiat. That doesn't always work. We hope that that will in fact be occurring around the country.

Both Mr. Langenberg and Mr. Pettit, I would like to ask you a question about the R&D tax credit. I assume that you would favor making permanent the R&D tax credit for basic research at universities and for contributions for equipment used in basic research in universities.

Mr. PETTIT. Yes, I think so. That is a long-range question. It is still kind of new, but I sure wouldn't want to see it expire at the end of 1985.

Representative LUNGREN. My next question is, then: Should it be expanded in any way?

And I am specifically thinking about extending the credit to equipment given to educational institutions that are used in the teaching of science. As I understand it now, the way it is written B&D credit can only be given for contributions of equipment used for basic research as opposed to the actual teaching.

Does that cause any problem with respect to universities?

Mr. PETTIT. On your first one, I think the general objective is incentives to encourage the partnership, and the more incentive you can give I would say the better. If it is still more attractive to do the research inhouse because of only partial credits or being done in the universities, then I would say increase it if that is really a handicap.

I don't know what the current figures are showing and how effective it is, but I would say increase it.

In terms of equipment, I think that this particular incentive ought to focus more on research equipment. That is a big enough job in itself in terms of the Federal dollars required, and if you open up eligibility to too many categories you won't do enough good in any one.

Mr. LANGENBERG. I would favor extension of that R&D tax credit. It wouldn't hurt to expand it. On the other hand, I think one needs to look carefully—and perhaps it is a bit too early—at just what effect the present credit is having, and I don't think we know very well.

I do remember at that conference last week one of the participants asking a question of one of the industrial representatives about the extent to which the existence of that credit entered into a decision that that company had just made to establish a very significant relationship with a major university, and the answer was that it was perhaps somewhere in the background and it certainly didn't hurt, but it was not a major factor in making the decision.

Well, that is just one instance, and one would need to do a rather careful study. But my point is I am not sure we know exactly how substantial an effect that is having.

I would make one remark about the question of research equipment versus teaching equipment. I suspect that—well, I think it would be useful to remove the restriction against teaching equipment, but I would say that I suspect that any research equipment that had been donated may very well be in use in part for teaching, if only in recognition of the fact that what you do when you train a graduate student who is doing research is to teach him or her. It is very difficult sometimes to distinguish between research and teaching and equipment for research and for teaching.

Representative LUNGREN. Well, that is part of my question. I just wonder if, in fact, we have created an intellectual distinction that does not exist, and I don't know a circumstance but I could anticipate a circumstance in which a university has to very carefully circumscribe the activity of its students so that they don't find themselves in difficulty with the tax law. That is the concern I have.

Mr. LANGENBERG. Yes.

Mr. PETTIT. Let me just add this. I fully agree, as a university person and a former researcher, that it is best not to draw a sharp line between what is research equipment and what is teaching equipment. It is best to not label it one thing or the other, but keep it flexibly available.

However, I think it is the current attitude around here that education is a State and local business, and that is accepted to some extent. We were successful in getting $6 million out of the State legislature for instructional equipment. They see that as their role.

It would have been hard, I think, to ask them for research equipment to help in the conduct of federally sponsored research. We can probably do better on seeking instructional equipment money. Maybe you ought to concentrate on the research part.

Representative LUNGREN. OK. That brings up another question if we are to concentrate on research, and I think that there is a recognition the Federal Government does that.

We had a bit of a difference of opinion in our testimony that we received in Silicon Valley and 128. In Silicon Valley the admonition that gave us was make sure you continue your commitment to basic research, but you really don't have to get all that involved in applied research on the Federal level; we will take care of that; the universities and private industry working together or private industry will take care of that.

We went out to 128, and they said, listen, we really think that it is important to emphasize applied research as opposed to basic research. Mr. Hatsopoulos, a former member of a number of universities' faculty and a very successful entrepreneur in 128, was very, very strong on that.

Maybe it is a dichotomy we don't have to create, but I would be very much interested in both of your responses to that sort of thing. I frankly didn't anticipate it, but that is what we received in those two different areas.

Mr. PETTIT. You have a real semantic problem. Mr. Langenberg and I spent hours on it with the National Science Board some years back; what is basic? What is applied? It is not a very useful debate if it takes up too much time.

I think it really came out that the applied research was—as far as the National Science Foundation was concerned—was that

having to do with extending the knowledge base into applied areas rather than actually doing hardware or solving field type problems, and that would include engineering, it would include medicine, and applied fields. You could call it basic because it is basic to the understanding of things, but it is also applied.

So I am not sure what the argument is, whether it was the same semantics being used in Boston as in California.

Representative LUNGREN. As I say, it was brought up without me even registering it, but they both seemed very, very vehement about it.

Mr. PETTIT. Continue doing everything you are doing.

Mr. LANGENBERG. Representative Lungren, I think I would urge you to ignore that difference.

I once wrote a moderately learned dissertation on the topic of applied versus basic research for the National Science Foundation, and the principal thing I learned from that exercise is that it is practically impossible to devise any automatically applicable definition that is of any use whatsoever, and I also learned that if you asked 100 people to distinguish between basic and applied research—where is there a boundary—you get about 100 different boundaries.

To a theoretical physicist all of chemistry and biology is simply applied physics, and to the mathematician—well, I need not go on.

I think that given the appropriate coupling mechanisms between universities and industry the question of who does the basic and who does the applied research in a particular relationship will simply take care of itself. Within the university, both basic and applied research is done. It depends very much on the personal taste of a researcher, and that taste will vary with the circumstances, and the circumstances will change almost from year to year. I really don't think it is a question worth spending a great deal of time on.

Mr. PETTIT. Congressman, there is a new boundary that has come into the lexicon, and that is the idea that research or development, R&D which is short term, should be done with private sector money and let the Federal Government undertake longer term.

I think that boundary is just as difficult, just as fuzzy as any others, and I hope there will be a generous overlap for some period of time until that is better defined. I don't think that the private sector can pick up the volume of good work being done in that gray zone, and I hope that the Federal Government will stay with it.

Representative LUNGREN. One of the interesting things that I think I have discovered through this whole process in looking at both high tech and the opportunity for us to be involved in an expanding economy that creates jobs is the essential nature of the educational institutions. We have, basic education—elementary, secondary, and so forth—and you mentioned that, Mr. Langenberg, in your testimony about it is ER&D, not just R&D.

In that vein, I would like to ask the three of you to comment on the observations you have about the quality of the output of the American secondary school.

I come at this from a number of different perspectives. One is on the Immigration Panel, coming up to this question about whether foreign-born students should have to return to their universities—I

mean their countries of origin before either teaching in our universities or working in high tech.

And one of the reasons we even got into that whole question on the Immigration Panel was the fact that many people believe we are not doing the job in educating our own youngsters, and even though that is the answer of making sure we don't continue to rely on foreign born so much—is not the short-term answer, that is at least got to give us some pause for our thoughts in the long term.

One of the major concerns I have is why we have such a low percentage, for instance, of participation in the professions and in the sciences among our minority youngsters.

One of the people that testified before us in Silicon Valley, Robert Noyce of Intel, said he things it is a great thing that young people all over the world who will apply themselves and work hard and be the best and the brightest feel they have an opportunity to come to the United States and participate not only in the scientific endeavor but the economic recompense that they can get from it.

I know the universities aren't at fault for all this, but I would just hope we have that same sort of situation with all the youngsters in the United States. Unless we start improving the quality of our elementary and secondary schools, however, I fear we are going to be continuing to have this same question year after year after year.

And so I would just ask the three of you, what observations do you have about the quality of our American elementary and secondary schools?

Mr. LANGENBERG. Congressman, we draw our students primarily from the Greater Chicago metropolitan area, and that includes the inner-city schools, it includes parochial schools, the strong parochial school system, and it includes suburban schools of a wide variety. And the answer is that the quality is very mixed. We are still finding superb students, but we are also finding that the product of many of the schools in the area leaves a great deal to be desired.

Is it getting any better? Not so far as we can tell.

In my prepared statement, I made the point that a failure at any point in the E part of the ER&D system really puts us at risk, and I think that probably the quality of our elementary and secondary schools is too low and that that probably represents one of the two or three most important national problems that we have today. It is a massive problem. It is not one that can be addressed solely by any sector of the society.

The one glimmer of hope that I see is that there are—there do appear to be increasingly here and there around the country efforts on the part of State governments, on the part of private industry, and on the part of the universities to establish relationships with and to assist elementary and secondary schools in beginning to address their problems.

Representative LUNGREN. Mr. Pettit.

Mr. PETTIT. Well, I think that there is so much that has been written about it, so many good national studies recently, that it is hard to add anything more than to just say from my own experience that the students that we are getting are just as bright as they ever were. They have not been adequately prepared in math,

English, and so we are spending a lot of university level money on repair work that is not well utilized, I would say.

There is pressure to improve the schools. We could add to that by raising our standards still higher. There is a certain limit to how much you can do there.

I think we are just in a time when the good math and science teachers are finding attractive jobs in industry.

In terms of the foreign born, I might just say we are addressing that at the high school level by importing a group of Germans, young German teachers to teach math in some of the Georgia high schools.

Representatives LUNGREN. Yes.

Mr. PETTIT. One got turned back by the immigration authorities because he had the wrong school district on his form. So he had an extra round trip across the Atlantic. But he is there now working.

Representative LUNGREN. Did they learn English with a Georgia accent before they came over? [Laughter.]

Mr. PETTIT. I am afraid it is mostly a German accent, but it is very good.

Representative LUNGREN. Mr. Kotula.

Mr. KOTULA. I think—and in the community college sector I know from personal experience—in Delaware that the good students today probably are better than the good students we received in 1967.

There are some problems, however. We have more people going on to higher education, and they are going into areas perhaps where they had some weaknesses. So, we had to provide developmental work.

Again, I mentioned that the average age of our students is 27.5 years. We have students who have been away from education for a number of years, so we must provide some developmental opportunities.

I think we need to look at the family. The good students, I think, are better. Those who receive parental support are doing well in school.

I think the faculties in the public schools or in the high schools of this country are better prepared today than they have ever been. However, there is a problem. I don't think it is one that is easy to solve.

Representative LUNGREN. I guess I would be surprised if you told me you saw a trend upward at this point in time because we sort of sense—at least I do in going to my district and talking to other Members of Congress going in their districts—that local school districts are getting more serious about standards and about requiring the hard courses, and that that has been a fairly recent phenomenon, the last couple of years.

So I would be somewhat surprised if you would tell me that you saw a trend. I would be very disappointed 8 years from now if I were to ask you that same question and you were to tell me that we saw the same thing.

We hear some good things, we see some good things on the secondary and elementary school level in terms of national testing, and so forth, in the school districts that I am aware of, but as I say,

we are coming up from behind and it is tough to try and see that manifest at the top.

Let me ask you something about the question of how you encourage or if you do encourage your professors' entrepreneurial spirit.

You have indicated that entrepreneurial spirit or the entrepreneurs are rare, and that is true, but there are some out there, and one of the questions we had asked both Silicon Valley and 128 was how come there seemed to be two sites in which there were a lot of entrepreneurs, many of whom came from the university, as opposed to other parts of the country that had strong basic educational programs, had outstanding institutions, and so forth, and we got varying responses.

My question is a more general one, and that is: Can you make an analogy to a professor's right to claim benefits of a patent with his or her right to receive royalties from the publication of a book? Do your institutions view that differently, and if so, why?

Mr. LANGENBERG. Well, if I might give that one a try. That is something that has always puzzled me.

Yes, my institution and my prior institution treated copyrights on books differently from patents on inventions. There are a number of things about universities that haven't changed much since the Reformation, and I suspect that may be one of them, and it has always puzzled me why a professor—as is normal, I think, in most universities—who writes a book—and it may be a very popular textbook. It was written within the university; it was perhaps tested on university students; certainly benefited from the faculty member's experience within the university; and most universities simply take no interest in the copyright on that book. If it turns out to be a big winner, the rewards go to the faculty member.

On the other hand, if a faculty member makes an invention, most universities nowadays take a very strong interest in the ownership of that invention, and most universities have policies—patent policies which in some way divide the benefits of any licenses of that patent between the faculty member and the institution.

It is different, and it is increasingly complicated now by the emergence of software as a major element in the technologically important products of universities. Is software like a book or is it like an invention? And a lot of universities are wrestling with how you handle that.

Mr. PETTIT. Well, I think there is another issue that you started off with. We might get back to that. What about the entrepreneurs?

As far as the faculty is concerned, I think policies like taxes are based only partially on rights. They are based partially on influencing behavior, and I think universities have encouraged the writing of textbooks—and I have written two or three myself—by letting the professor claim the royalties. They aren't that great, as a matter of fact.

Representative LUNGREN. I was going to ask whether that could be one of the other reasons why patents and copyrights are treated different, seriously.

Mr. PETTIT. Well, some best sellers among college textbooks, of course, bring in a lot of money, but typically the advanced engineering or science book doesn't bring in a great deal.

But on the other hand, I think, as a professor and then later as an administrator, the merit in having that policy of letting the professor keep what he could is because you want to encourage him to do that sort of thing. It helps classes, it helps the university get well-known, and there are a lot of other reasons why you want to encourage it.

I think historically there have been far more textbooks than there have been patents of any particular value. Of course, in the last 30 or 40 years we have had sponsored work, and in general the Federal Government, through its agencies like ONR, has been fairly generous. I would say that they retain first right for a nonexclusive royalty free license for the Government to use that work, whether it was military or whatever.

But if they chose not to pursue it, they the Government, then the university and the individual faculty member had the right to exploit the commercial rights. Sometimes we packaged them and sold them to the research corporation or one of the corporations and got some steady flow of money.

We are examining that a little more carefully now. We think now there is incentive—I mean a desire to provide incentive for professors to be creative and to have them share in the royalty, to bring royalties into the university as well.

So we have a fairly flexible policy, and the range of flexibility embraces how much the individual does entirely on his own or how much is contributed through facilities and resources of other kinds by the university itself, and it is somewhat individually negotiable, case by case.

Representative LUNGREN. I was just wondering if that might be one means in certain circumstances of enabling universities to retain the talents of people who otherwise would be attracted in the private sector exclusively. I know that is a continuing problem.

How do you keep some of your best people teaching? Do you have any ideas on that?

I suppose we could say if the Federal Government had money we could give you money to keep certain people there. I am not sure that is going to happen, but what types of things are you looking at from a university level to try and retain your best people in your technical areas, in your engineering areas from being able to go out in the private sector and command a much higher salary?

Mr. LANGENBERG. I think we have a natural advantage in that there are in the universities certain features of the academic life that some people find very attractive and wish to stay associated with. That advantage, however, is not enough if the financial rewards within the university and outside the university differ too greatly, and it is also not enough if the university itself puts up impediments to a faculty member's becoming involved in outside activity.

I think in the past a good many universities have been overly restrictive in that respect for a variety of reasons, including the desire to protect the university's interest in the serious attention and devotion of time of the faculty member, some cases due to con-

cerns either within the university or with the university sponsors, perhaps the State, about faculty conflicts of interests, and the like, and I think a good many universities have had rather rigorous and rather rigid rules about what a faculty member could or could not do on the outside.

I think that has frequently led to faculty members being put in the position of saying if you wish any significant involvement with this corporation on the outside, which might be your own brand new brainchild, once you get involved there you have got to leave the university. There can be no dual citizenship, so to speak.

I think a good many universities are beginning to reconsider those policies and make much more flexible arrangements.

I like to remind people that in other fields we have been doing this sort of thing for many years. The arrangements between university schools of medicine and their clinical faculty are unimaginably diverse and hugely flexible, and I don't know why we can't do that with engineers, with architects, and with others.

Representative LUNGREN. I don't know if medical schools would exist without that arrangement with their clinical faculty.

Mr. LANGENBERG. Exactly so. Exactly so.

Representative LUNGREN. So you don't believe that academic freedom would necessarily be compromised by this sort of relationship?

Mr. LANGENBERG. No. I think you have to pay attention to it. You have got to be careful. You have got to preserve those eternal values that have given universities their permanence, but you can be flexible and still get the job done.

Representative LUNGREN. Let me just ask—and I think, Mr. Pettit, you were about to respond to it because I used it as a preface rather than a question—but it has intrigued me.

Why have we seen the emergence of the high-tech industries especially concentrated in Silicon Valley and Route 128, and why didn't we see the same sort of thing in Chicago or Wilmington or Atlanta? They all, all three of those placed I have mentioned, that you represent have fine outstanding educational institutions, large commercial firms.

In giving the history of these two other places, people who were part of it said, well, you have to realize we had a tremendous infusion of Federal funds that came directly with the effort in World War II. I think you could make the same argument in Chicago. You had in Chicago electronics firms. Some of the biggest and the first electronics firms were there, and I hope you don't take it as a criticism. I am just trying to find out why you would find it in those two areas, where one of the amazing phenomena appeared to be that you had a lot of people who had some sort of entrepreneurial spirit. You mentioned that it is rare, but it seems to be less rare there or there was something that encouraged people there to go outside where they were and to try their best shot out in the commercial field.

Do you have any thoughts on that?

Mr. LANGENBERG. We are trying to figure out the answer to that question in Chicago.

I can speculate about what some of the aspects of the answer might be. If you look at the other successful entities that you have

pointed to—Silicon Valley, for example—you very frequently find origins in individuals, and I think from what little I know about the history of Silicon Valley you would have to point to Frederick Terman as an absolutely major feature in the development of what led to Silicon Valley and what led to the development of Stanford University in its engineering and scientific aspects.

It is true Chicago has a number of distinguished academic institutions. I do not believe that in any of them a Frederick Terman has turned up. There has not been that thrust to the outside.

On the financial side I have seen some recent statistics that suggest that there is very substantial venture capital in Chicago, much of which is invested in California. Why?

Representative LUNGREN. For which we thank you.

Mr. LANGENBERG. Well, I hope we can make that cease rapidly. [Laughter.]

We have been talking to venture capitalists in connection with this developing technology park we have got, and it is not that they don't want to invest in Chicago. They don't know how. They don't know where to find the people. That is one of the things that I hope we can do through the technology park.

Chicago's industries, some of them, have not been notably innovative. Now, remember that one of Chicago's major industries is—was—the steel industry, and that is not an industry that has shown a great deal of interest in new techniques and new technology, at least in this country.

That is not the case with others. The pharmaceutical industry is a major Chicago industry, and there is just all kinds of foment there.

What it really comes down to, I think, in part is not the absence of resources of the kinds that you know are necessary, intellectual resources, research institutions, money, space. It comes down, I think, to attitudes, attitudes and the style. The economic community, the bank community in Chicago has, I think, been a little bit less than adventuresome in some of the things it has done, the Continental Bank to the contrary notwithstanding. It just hasn't been the style in Chicago, and I hope it will become the style, and there is some indication that it will.

Representative LUNGREN. Well, you might be happy to know that when we had, I guess, six of the top venture capitalists from Silicon Valley testifying they mentioned that there is an excess of venture capital in Silicon Valley. There is more money available then there are ideas coming out, and they are looking for parts of the country to be involved in. So maybe some of that California venture capital will find itself in Chicago.

Mr. LANGENBERG. I will leave you my card. [Laughter.]

Mr. PETTIT. Well, I can draw some contrast between the Stanford scene and the Georgia Tech scene, if you want to put the university handle on the discussion.

I think Frederick Terman was a very important factor. He was my Ph.D. professor in the late 1930's and was dean of the engineering school when I was hired, and then I succeeded him, which was a difficult act to follow.

But there was a very positive attitude toward industry on his part, and this was tolerated by the then president of the institution

and tolerated by other parts of the university, though not necessarily copied.

The second thing was that at the time industry was growing. By that I mean established companies, like Lockheed, who moved their missile and space division there around 1950, and Sylvania, now a part of GT&L, moved a big activity there, and IBM and Philco-Ford and others. It was a big factor in their decision that we were there and that we were heavily engaged in, I must say, federally sponsored research in areas of interest to them, and there was immediate technical interchange between their people and our people.

The small companies, the entrepreneurs, do not just emerge right out of school. They go to work for several years with an established company, get their self-confidence, get some money saved aside, and then they break off.

You might say, well, Hewlett and Packard were an exception. Not so. Packard had worked for GE for a number of years before going back for graduate school, and Hewlett had other things to do, too.

The others tended to come—Varian Associates, formerly Sperry employees. They decided they didn't want to live in Long Island. They would rather be back at Stanford.

And I think, on the other hand, in Silicon Valley the people who left the established companies—and Hewlett-Packard is now spawning its own entrepreneurs, Steve Jobs in the Apple Computer operation for example—they choose to stay there. They like it there. Maybe they don't choose to stay in Greater Chicago.

And their expansion, in fact, of Motorola took place in Phoenix because that is where one of their leaders wanted to have it.

So Georgia Tech, on the other hand, is some 20 years behind on the growth curve of research. The year I went there, 1972, we had only 8 million a year in grants and contracts; 10 years later we had worked our way up to 80 million, a tenfold increase in 10 years. So we are now on the steeper part of the curve and you see things happening.

Some spinoffs have occurred, like Scientific-Atlanta, and that has now grown and they are spinning off new companies. One of the newest is in our incubator. I have to view that with mixed feelings—the loss of seven good people, but we have lost our own from our Georgia Tech Research Institute as well.

So the process is underway. It is climbing up, but it is a long way behind.

We find many of our graduates who come from other States or other parts of Georgia, even, want to stay in Atlanta and start their own companies. Many come back and take lesser jobs.

So I think you are going to see it happening there. We do have a very positive attitude toward industry, very cooperative with them. Not all universities are, and I think if you want to encourage this interface—to use a badly overused, misused word—you might limit your activities to those where the environment is favorable, where the attitudes are favorable rather than spreading it indiscriminately.

Representative LUNGREN. Mr. Kotula.

Mr. KOTULA. Yes; in Delaware the same question has been asked for many years. The answer was that we had high individual

income tax rates, graduated income tax. This year the general assembly passed a blue-collar jobs bill which requires the—also included a tax cut—executive department to find 18,000 new jobs over the next 2 years. In a State with a population of 600,000, that is a lot.

I think you are going to see Delaware becoming more active in economic development, particularly as it relates to the chemcial and pharmaceutical industries.

As I mentioned earlier, the banking laws were changed in Delaware 4 years ago. We, in that time period, have attracted major banks to Delaware.

I think the major reason again is the income tax. That has been changed. We certainly have a trained labor force to attract the high-tech industries, and I think you are going to see us become more active in the future.

Representative LUNGREN. It is always very interesting when I posed those questions in route 128 and Silicon Valley they mentioned many of the same things as all of you mention, and they stressed role models. They suggested they wouldn't have done what happened if it hadn't been for a few individuals, and they mentioned William Shockley, among others, and mentioned about happenstance, how people just happened to go back to where they grew up, or where they liked the weather. That, combined with just the serendipity of a couple of people wanting to start in a particular area, seemed to create the environment where others tried to follow.

The same thing happened with venture capitalists. They saw that some were succeeding and encouraged others to, and so you had a whole new financial enterprise develop in an area that was a little different than perhaps you had in other areas.

They also managed to tell us, however, that in fact the great growth was enhanced in the 1970's by some changes in the tax laws on the Federal level—capital gains tax rate drop.

When I asked them what would happen if we were to increase it back to where it was, they told me in effect that you would dry up a lot of the spin-off companies that you could anticipate being created over the next couple of years.

You have been very generous with your time, and I don't want to keep you over the time that we indicated that you would be here—but let me just ask you this question.

Let's say that you identified a need for new curriculum developments in something different. Let's just say laser technology, for instance.

Can you take us through some of the budget and administrative decisionmaking that might be involved here? How quickly are you able to respond to a perceived need for a new curriculum development, and does the Federal Government assist you in that or do we impede your progress in that because of some of the things that you have talked about in your testimony here?

Mr. PETTIT. Well, I would have to start off by saying that in a research university, at least, undergraduate curriculum follows graduate curriculum, graduate curriculum follows research. As you have research going into new and promising areas, courses follow

at the graduate level. Their content works its way down into the undergraduate courses.

So in a sense you are exercising or exerting a substantial leverage already, just through helping us with the promising new areas of endeavor.

We started a new microelectronics research center a couple of years ago. Very simply, I just decided we ought to have it because I found there were nine faculty doing research in that, and I thought it might help them do what they were already doing if we printed some letterheads and got them meeting with each other. So we have it. Now, we have $2 or $3 million of research, a lot of synergism, good laboratories, and courses are appearing and they will find their way.

I think you don't want to have a new curriculum for every new research area, still stay with the basic disciplines, but the content of the courses will change a great deal.

You know, once I initiate something this way, then I have to let the faculty massage it and have their debates over what should be in the courses and what should be in the curriculum. That is a very tedious process. It will move, I would say, faster if you have energetic people doing your things, and that is again where I can get in the act in the process of putting together a faculty for the future.

I don't think we are going to see a lot of new curricula full-fledged.

There is another area that is of real interest where we are being helped, and that is in the computer integrated manufacturing systems. We have gotten a couple of major grants from IBM and have a material handling laboratory as part of that, with Federal support through NSF, which will taper off. But we have no problem whatever with filling in behind with industry support. So that is going to provide a great stimulus to new thoughts.

Let me just throw out one thing on that subject because it hasn't come up; it is not on your list of questions.

I think, in my study of the Japanese situation, that the universities there are very traditional in what they teach in the curricula. The big service they render, to certain companies at least, is their highly selective admissions process whereby the big company knows that Tokyo University will provide the best young people.

But beyond that, there isn't the level of cooperation that we have even now in terms of research, and so on. There is consulting, yes, but most of the graduate and advanced education goes on within the companies themselves. Of course, they have a cultural advantage with career-long employment. We can't replicate that.

But we are already a long way in cooperative relations between industry and universities and the Government, and if we can enhance and use that advantage we have, we can regain some leadership, I think.

So anything that you can do to encourage, to expedite, to facilitate, sponsor that kind of thing, it will be very important.

Representative LUNGREN. Very interesting observation because in hearings we have had about the Japanese experience we heard that there is not the interchange of information through professional societies that we take for granted here, that there is a pro-

prietary sense in that information, and even though they may go to professional societies they don't feel as willing to exchange information as our people, both in academia and in the private sector, feel, and that that ought to be one of our strengths.

I think you just indicated if we can enhance that as opposed to trying to copy what they are doing we might stand a better chance of competing.

Mr. LANGENBERG. Congressman, I would like to add just one example to Mr. Pettit's comments about curriculum. I think we are in the middle of an example of the development of—you could call it—a curriculum right now, and I think it illustrates some of the complexities and the long time scale in which these things occur.

There are a collection of activities which are variously labeled computer science, computer engineering, and sometimes information science. They have come out of research that now goes back perhaps 30 to 40 years. Our universities, I think, are still wrestling with the question of what are those things, what kind of curricula should reflect them, and where should they be located in the university.

While I was at NSF I once asked one of our computer science people where the computer science departments were within a university, and the answer was one-third of them are in the school of engineering and one-third of them are in the school of arts and sciences and in the remaining third of universities they have one in each of those places, and that in fact is the case at my own institution.

We have what amounts to computer engineering in engineering, and we have computer science in the math department. Not only that, we have got some of that tucked away in various other places. Some day we are going to have to decide whether to have a department or school with its own curriculum in computer science, but that day hasn't arrived yet, and it any take a couple of years, may take a decade or two.

Representative LUNGREN. Mr. Kotula.

Mr. KOTULA. With respect to the community college, we have had the flexibility to start new programs and/or new courses. I have seen courses develop in 2 weeks. Now for an entire curriculum it takes a little longer, but the process that we use in Delaware is that we would ask our friends in business and industry to advise us, through an advisory committee, what are the jobs in Delaware. We will not start a program at Delaware Technical and Community College unless there are jobs in Delaware.

The Federal Government has been helpful in the past through the title III, Strengthening the Developing Institution Program, and providing funding for new programs. The only limiting factor that I can see in Delaware is the receiving of funds, if we don't get them through title III, from the State of Delaware in order to start a program.

Again, we use the people from business and industry to work as lobbyists for us in the general assembly to receive funds for programs.

Programs can be started very quickly. The way the legislation is written in Delaware, it is the general assembly of the State of

Delaware and our board of trustees who determine what new programs we will have, not the faculty.

Representative LUNGREN. Very different. I doubt people would want us to extend that on the Federal level, have Congress determine it. [Laughter.]

Let me just say that I appreciate the testimony of the three of you. It has been very, very helpful as part of our ongoing inquiry as to what the Federal Government can and should not do in making sure that in a growth-oriented economic environment we continue to do those things that are necessary to maintain it, and one of the extremely important questions is: What is the function of the university in there other than their basic traditional, absolutely essential job of dealing with basic knowledge? How do we use the university setting and the college setting as a conduit for ideas from academia to the private sector?

And I want to tell you that you have been very, very helpful, very generous with your time and very helpful in your comments, and I want to thank you.

The committee stands adjourned.

[Whereupon, at 12:05 p.m., the committee adjourned, subject to the call of the Chair.]

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